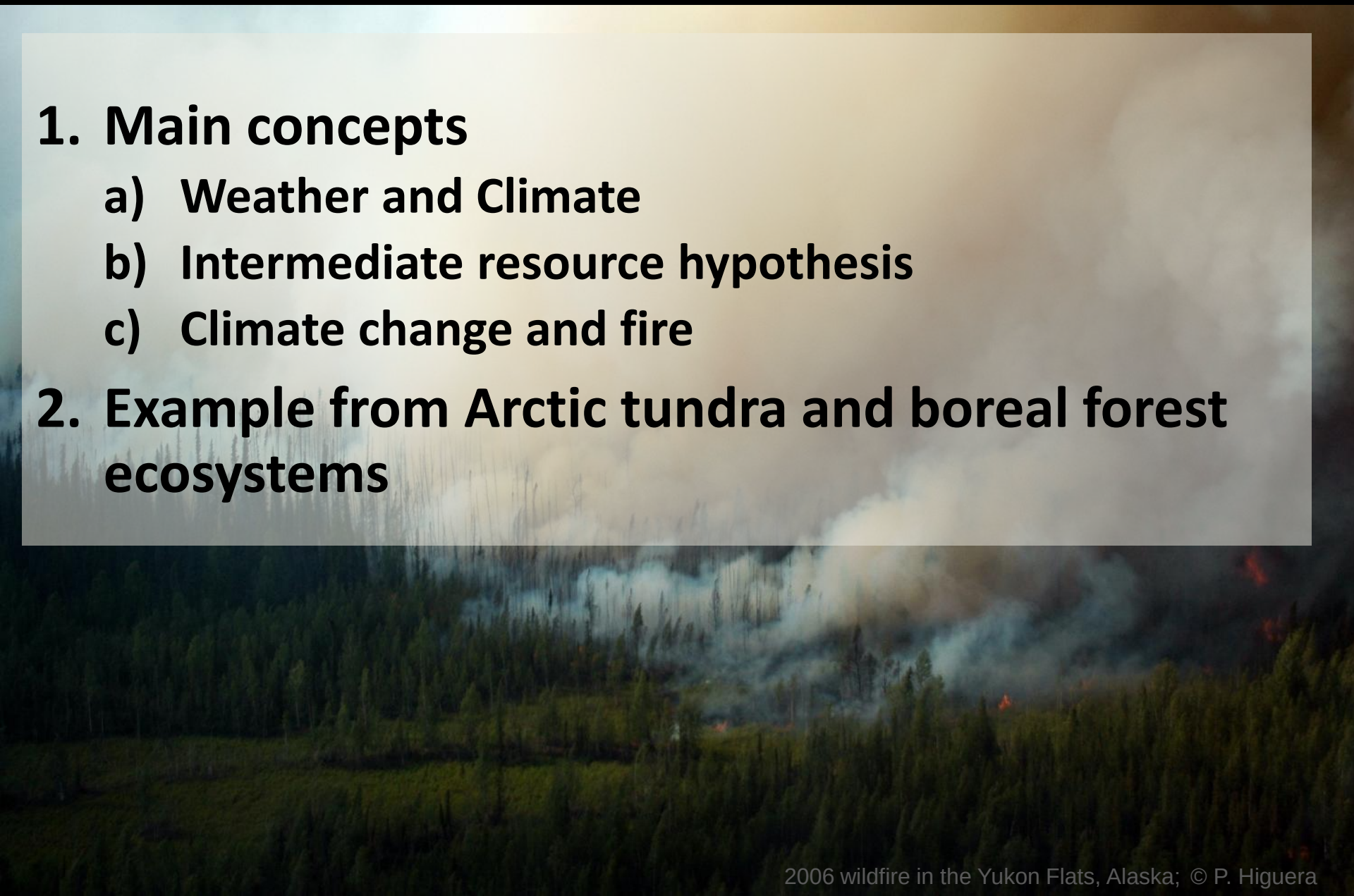
Introduction to fire-climate relationships: concepts and applications

Adam M. Young
Ph.D. Candidate, Univ. of Idaho
amyoung@uidaho.edu
University of Idaho
College of Natural Resources

September 15, 2016

Outline

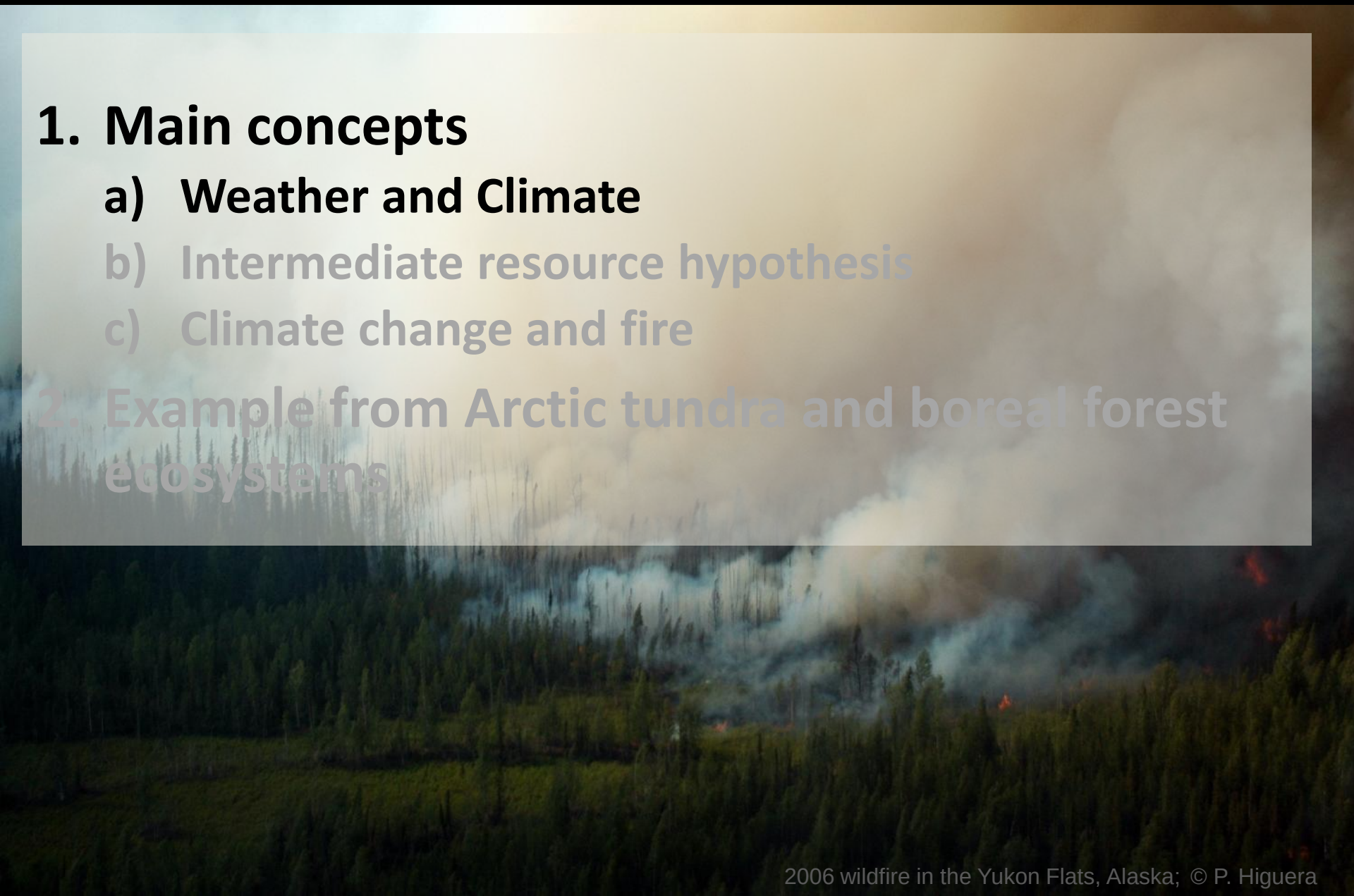
1. **Main concepts**
   a) **Weather and Climate**
   b) **Intermediate resource hypothesis**
   c) **Climate change and fire**
2. **Example from Arctic tundra and boreal forest ecosystems**



2006 wildfire in the Yukon Flats, Alaska; © P. Higuera

Outline

1. **Main concepts**
   a) **Weather and Climate**
   b) **Intermediate resource hypothesis**
   c) **Climate change and fire**
2. **Example from Arctic tundra and boreal forest ecosystems**



2006 wildfire in the Yukon Flats, Alaska; © P. Higuera

Weather and Climate

Weather

- Current meteorological conditions
- Comprise “events”
- High-frequency timescales (< 1 month)

Climate

- Statistical summary of meteorological conditions
- Cumulative in nature
- Lower-frequency timescales (1+ months)

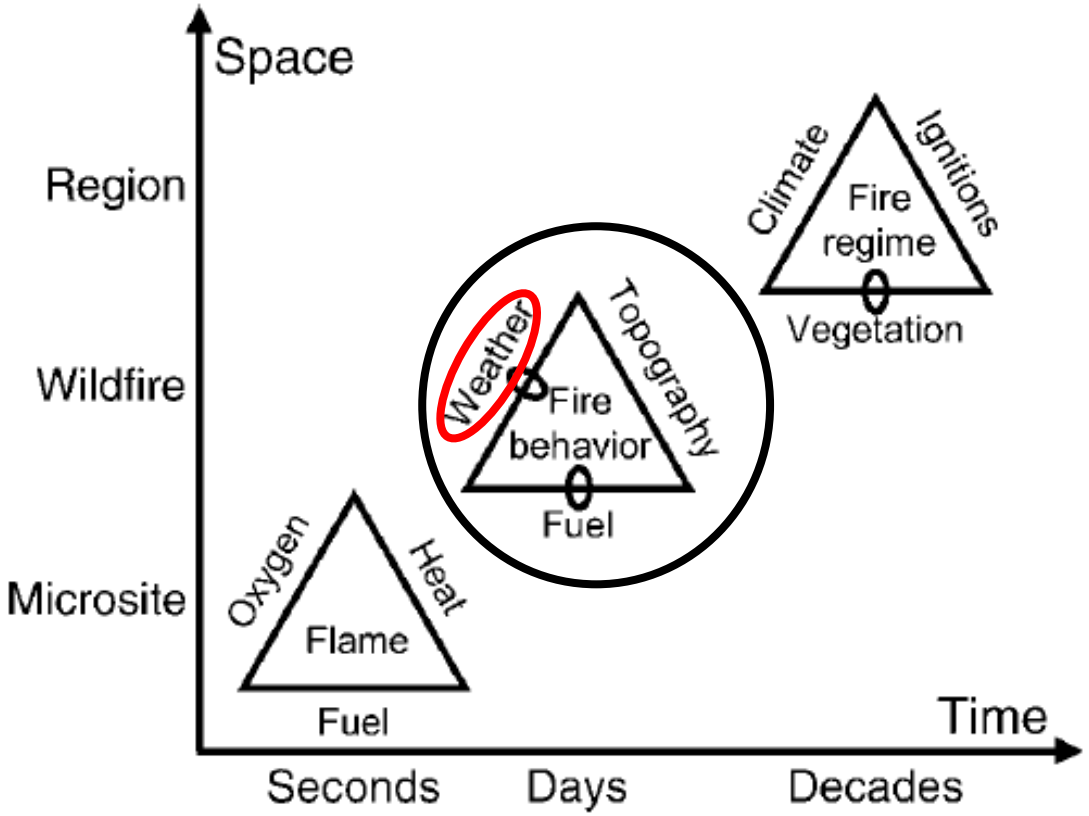
*Adapted from a slide provided by J. Abatzoglou, Univ. of Idaho

Fire-climate relationships: main concepts

- Wildfire is ***climate*** enabled and ***weather*** driven

Fire-climate relationships: main concepts

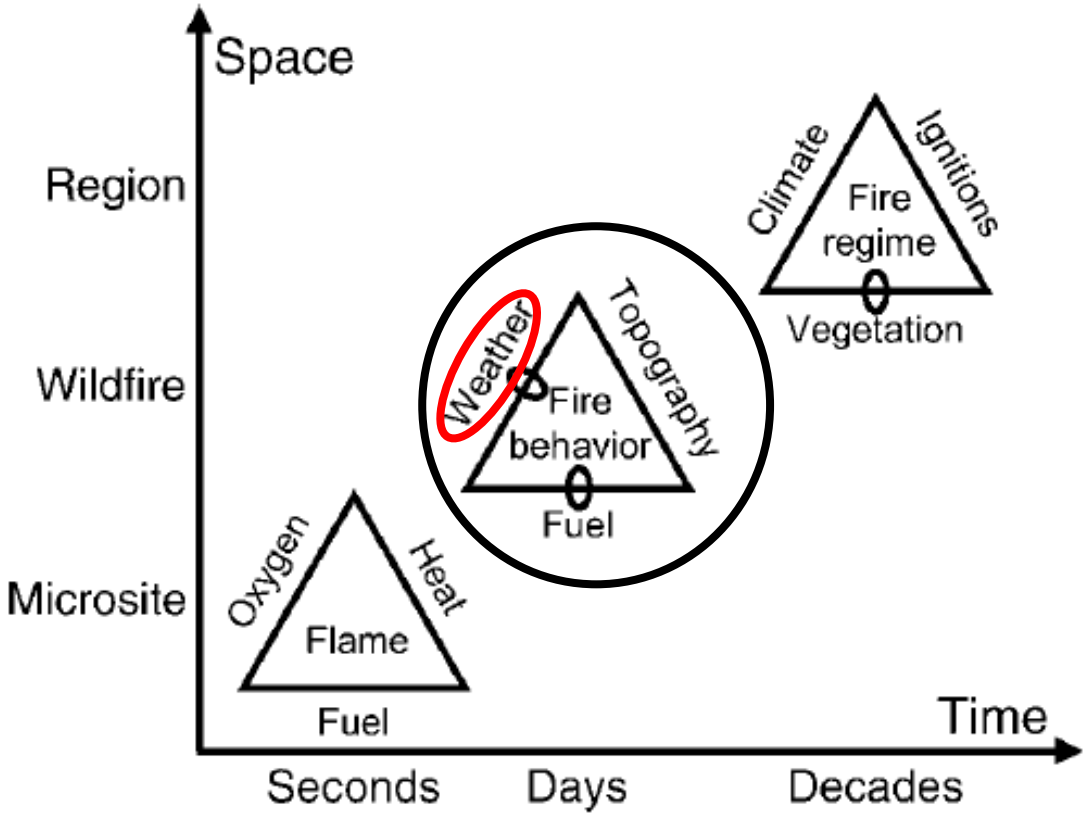
- Wildfire is ***climate*** enabled and ***weather*** driven



Parisien and Moritz 2009, Eco Mono

Weather and Climate

Weather conditions are an important control over the ignition and behavior of individual fire events

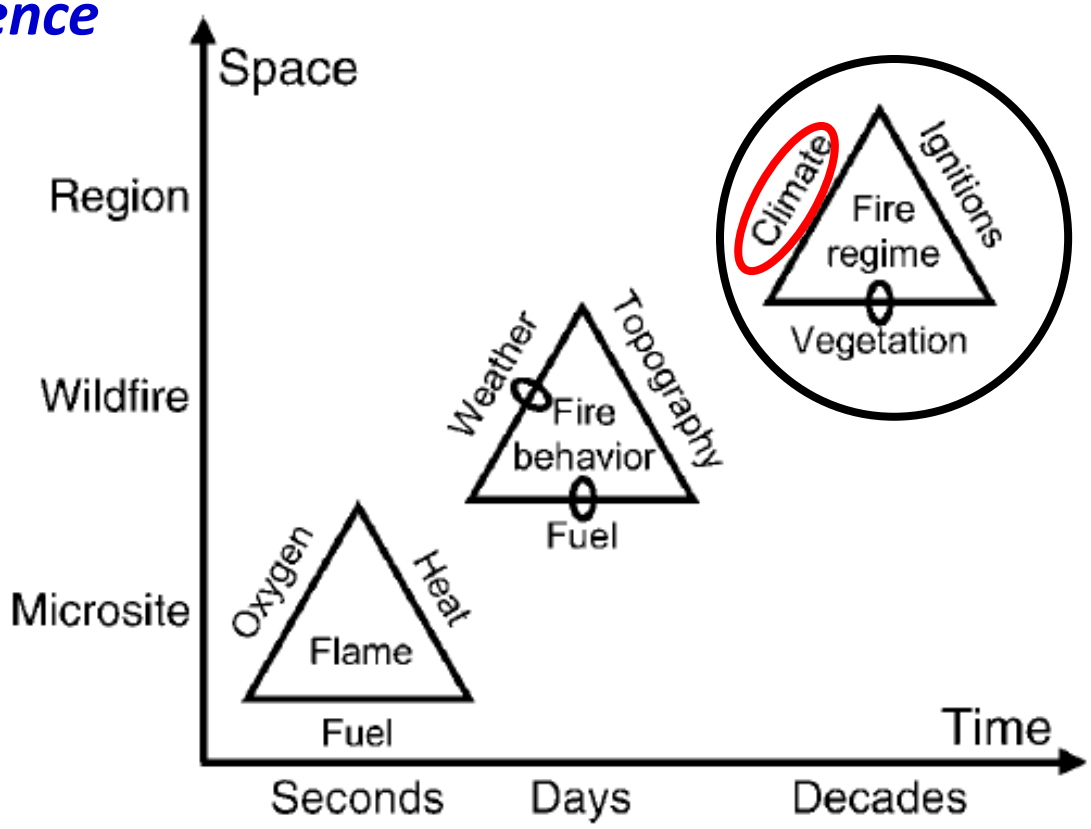


Parisien and Moritz 2009, Eco Mono

Weather and Climate

**** Fire-climate relationships: need to consider longer timescales and/or larger spatial regions***

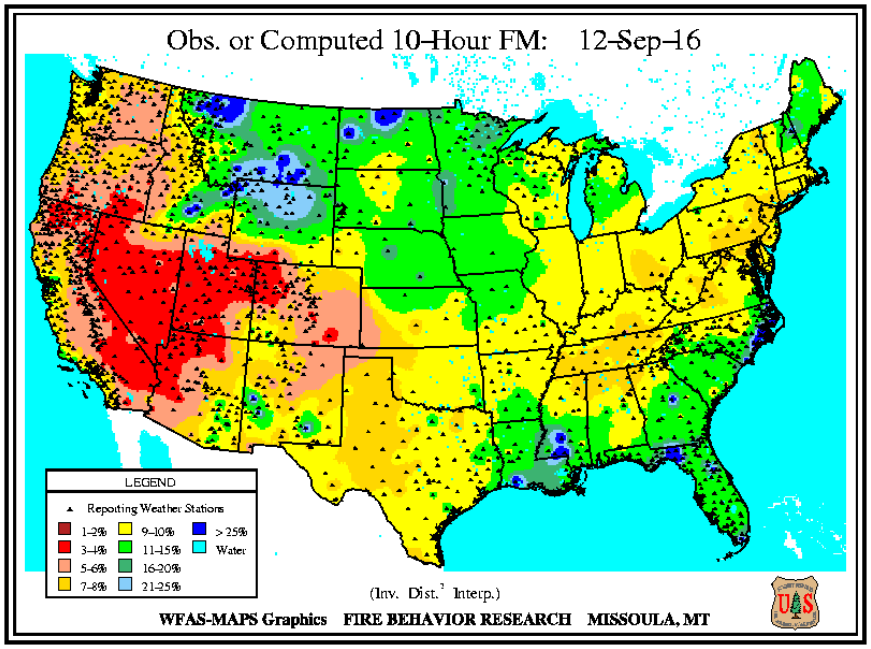
**** How does climate influence and control fire activity?***



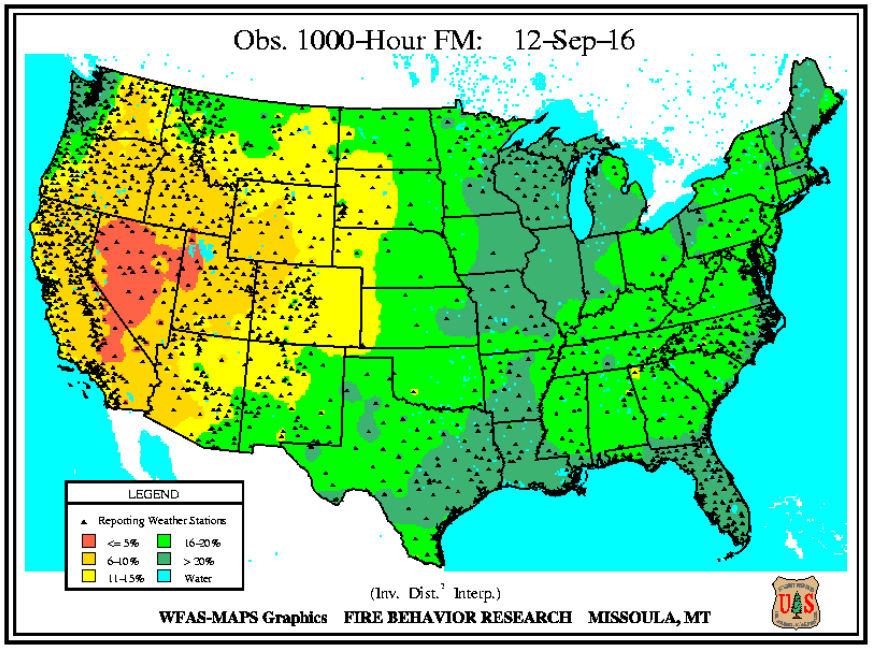
Parisien and Moritz 2009, Eco Mono

Weather and Climate

***Short-term fuel drying**



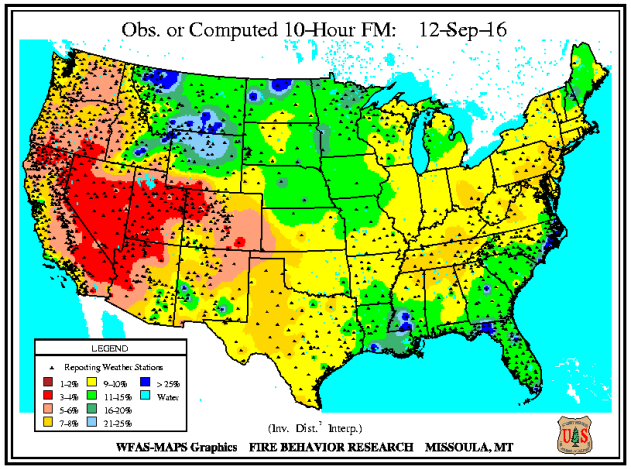
***Long-term fuel drying**

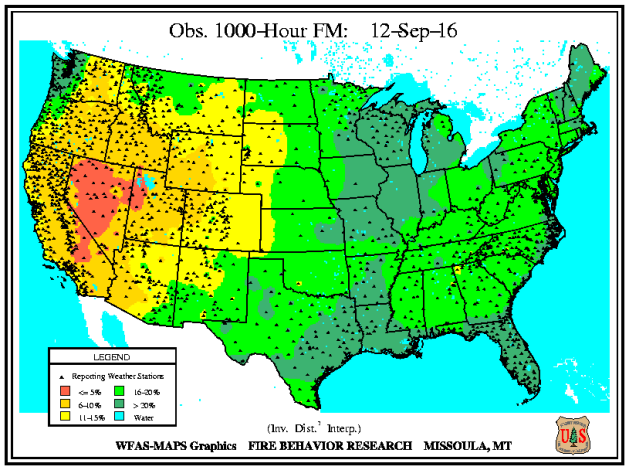


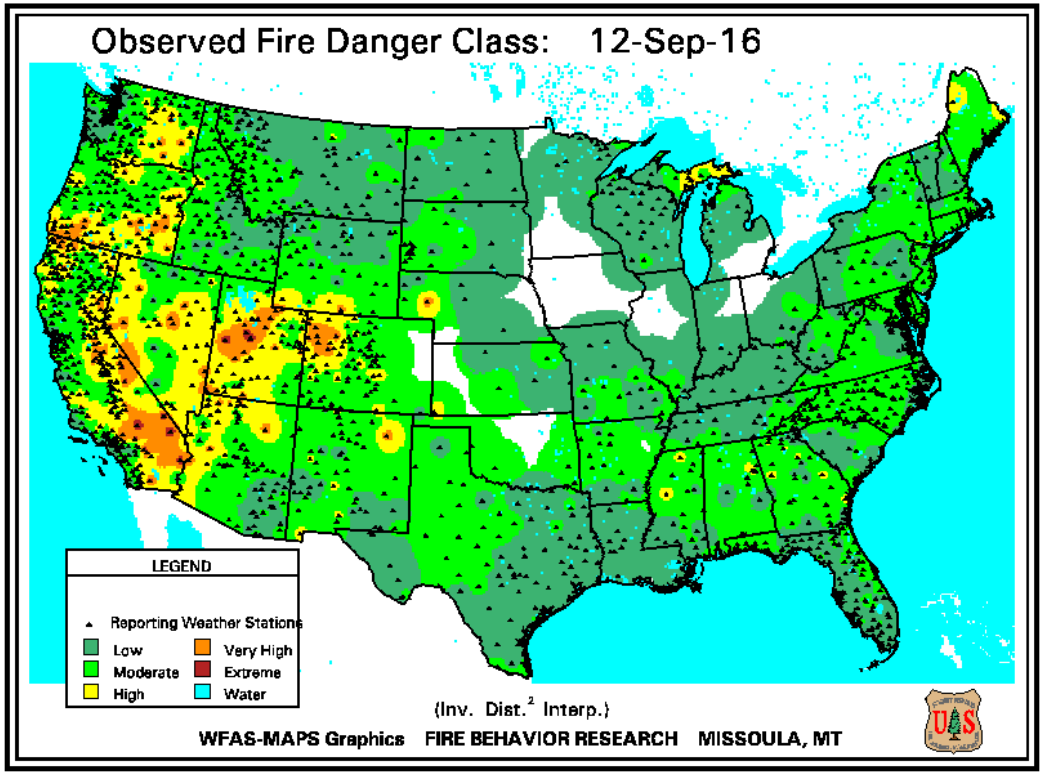
Which is a better predictor of fire activity during the course of a year? Why?

Weather and Climate

Fire Danger – Static and dynamic factors of the fire environment that influence ignition, spread, likelihood of containment and fire effects.







Fire Danger Rating System

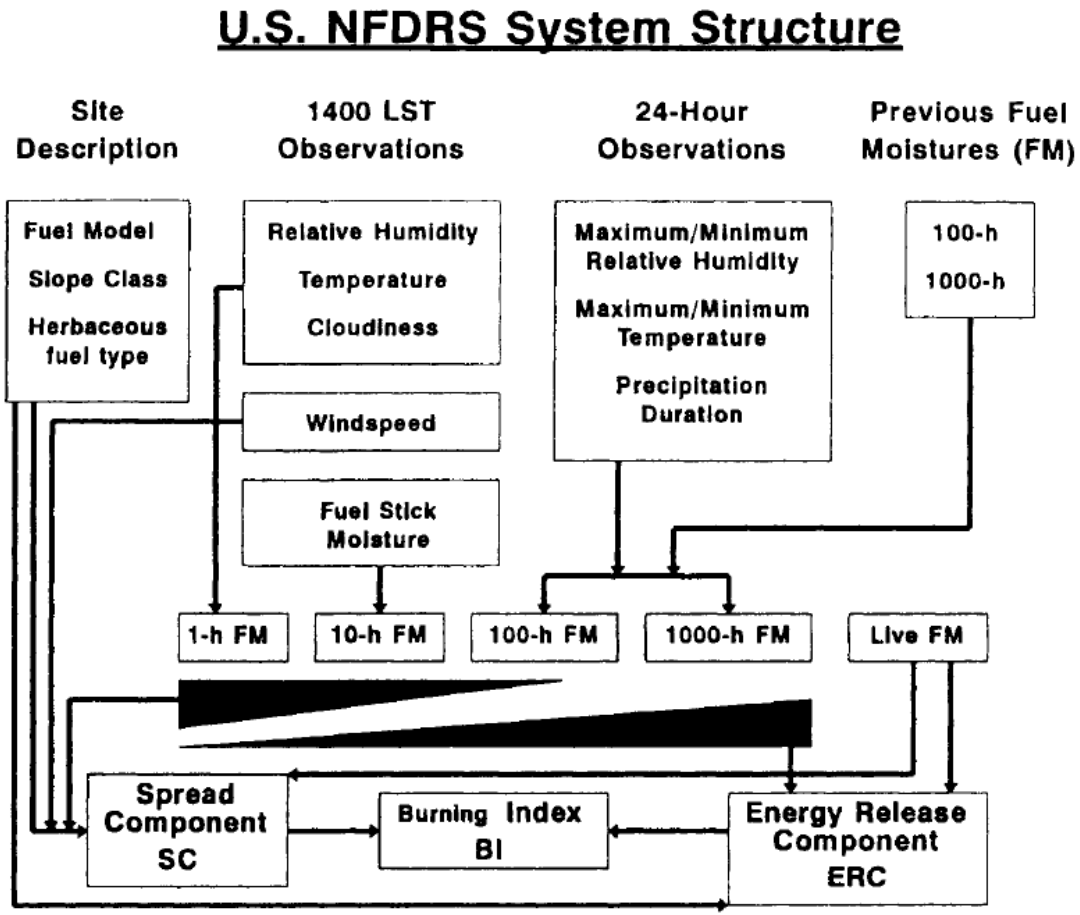
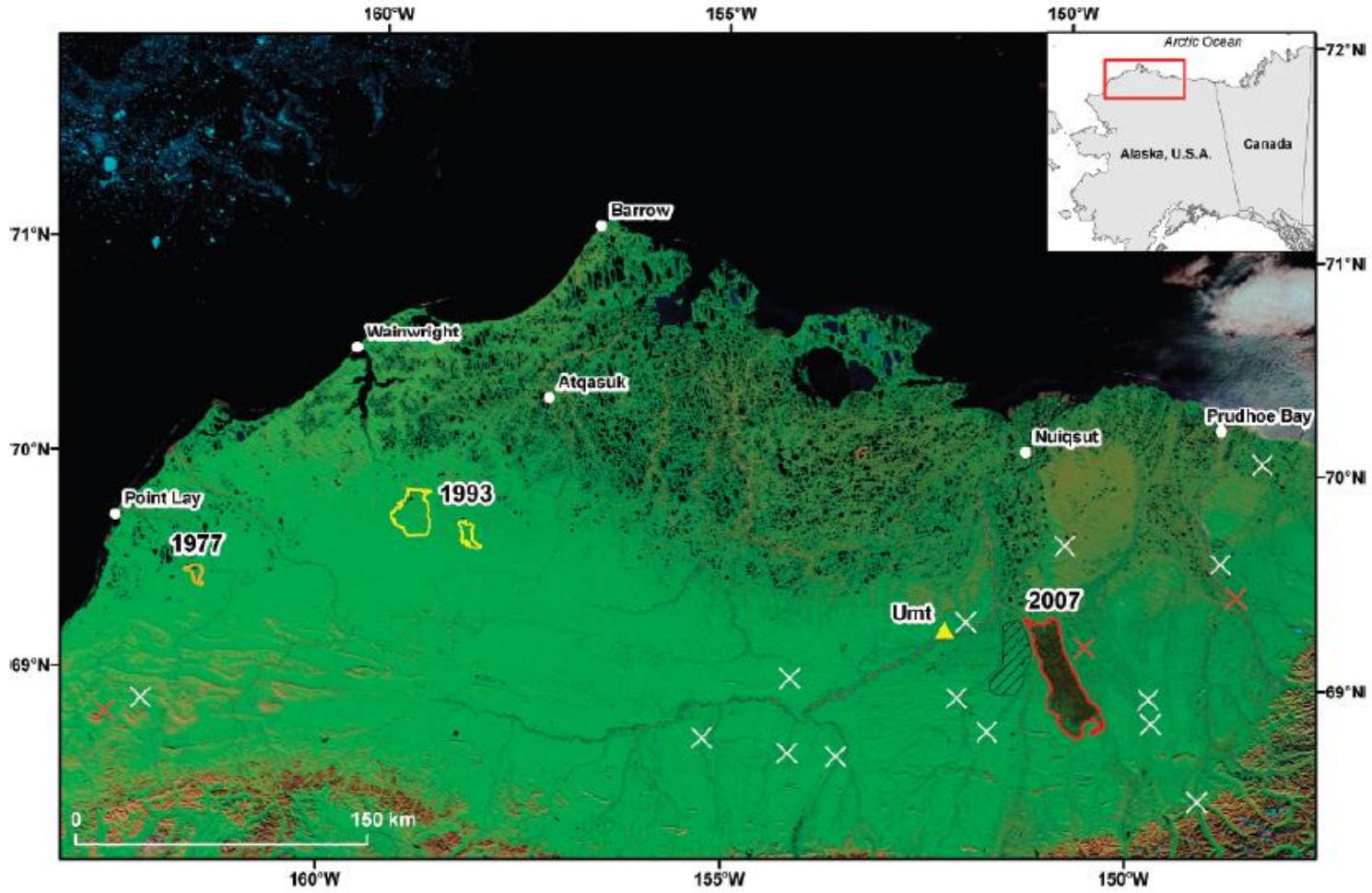


Fig. 15.2: The structure of the U.S. NFDRS illustrating the links between site variables, weather observations, fuel moisture, and the final index values, from Pyne et al. (1996; Fig. 4.22).

Weather and Climate

Example: Anaktuvuk River Fire (ARF), North Slope, AK



Jones *et al.* 2009, *AAAR*

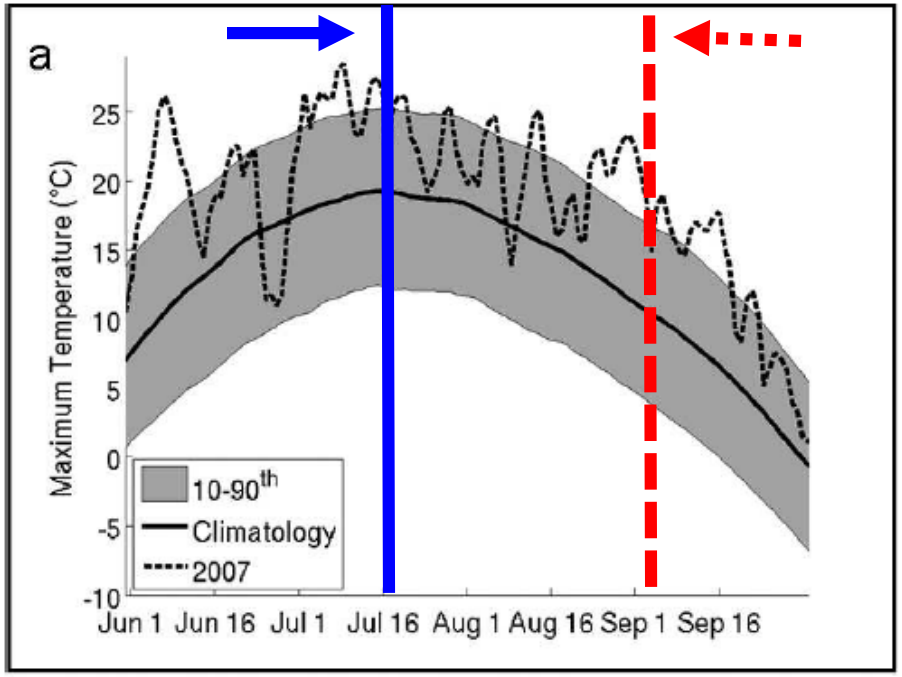
Weather and Climate

Example: Anaktuvuk River Fire (ARF), North Slope, AK

****Anomalous warm and dry weather in the months prior to the fire***

**** Climate enabled landscape for burning***

Ignition *Rapid Expansion*



Ignition *Rapid Expansion*

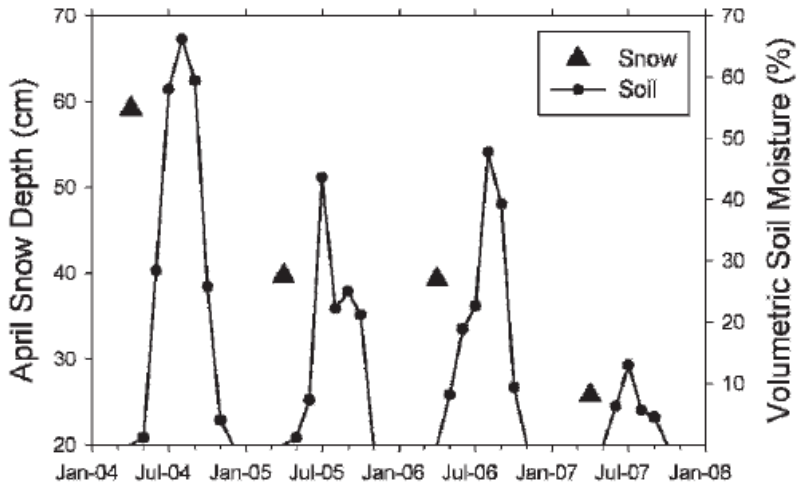


FIGURE 5. Accumulated snow depth measured at the end of April (cm) and volumetric soil moisture content measured at 15 cm below the ground surface at the Umiat meteorological station located 65 km west of the ARF between 2004 and 2007.

Jones *et al.* 2009, *AAAR*

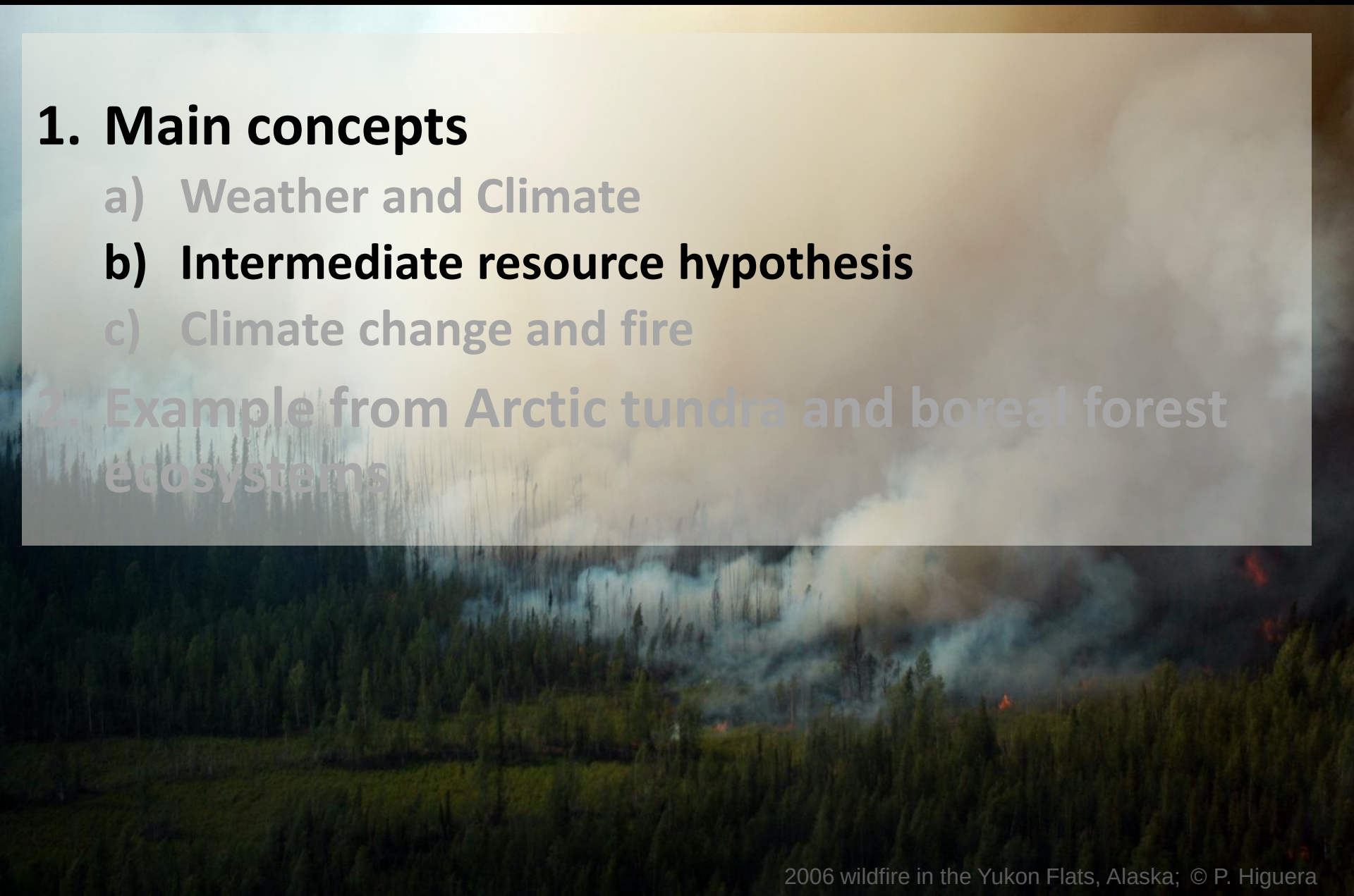
Fire-climate relationships: main concepts

- Wildfire is ***climate*** enabled and ***weather*** driven

  - Weather is an important control over individual fire events due to factors such as lightning, wind, fine-fuel drying
  - Climate enables landscapes for large fires to occur in months-years prior to fire event

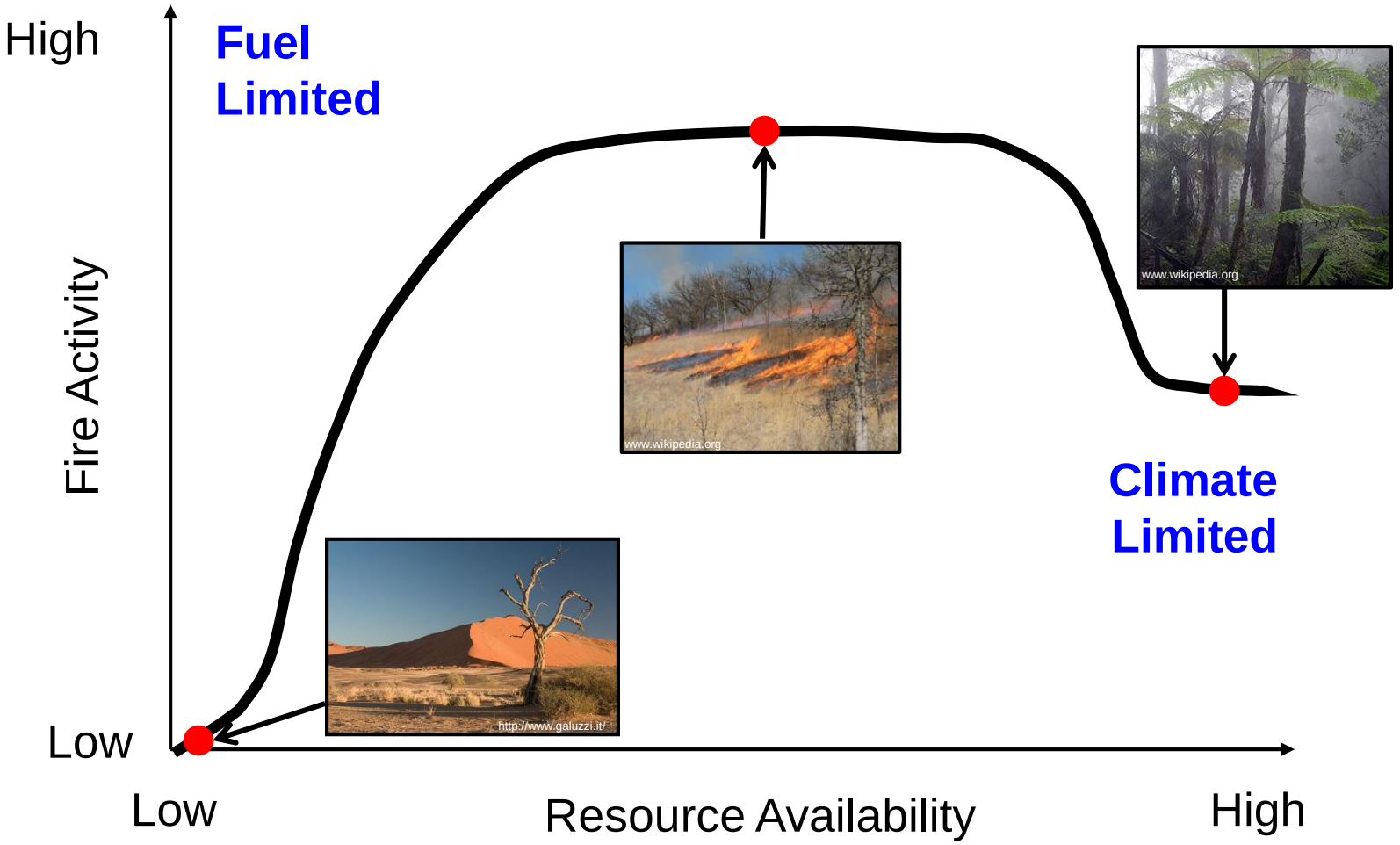
Outline

1. **Main concepts**
   a) Weather and Climate
   b) **Intermediate resource hypothesis**
   c) Climate change and fire
2. Example from Arctic tundra and boreal forest ecosystems



2006 wildfire in the Yukon Flats, Alaska; © P. Higuera

Intermediate resource hypothesis



Adapted from Krawchuk and Moritz. 2011. *Ecology*

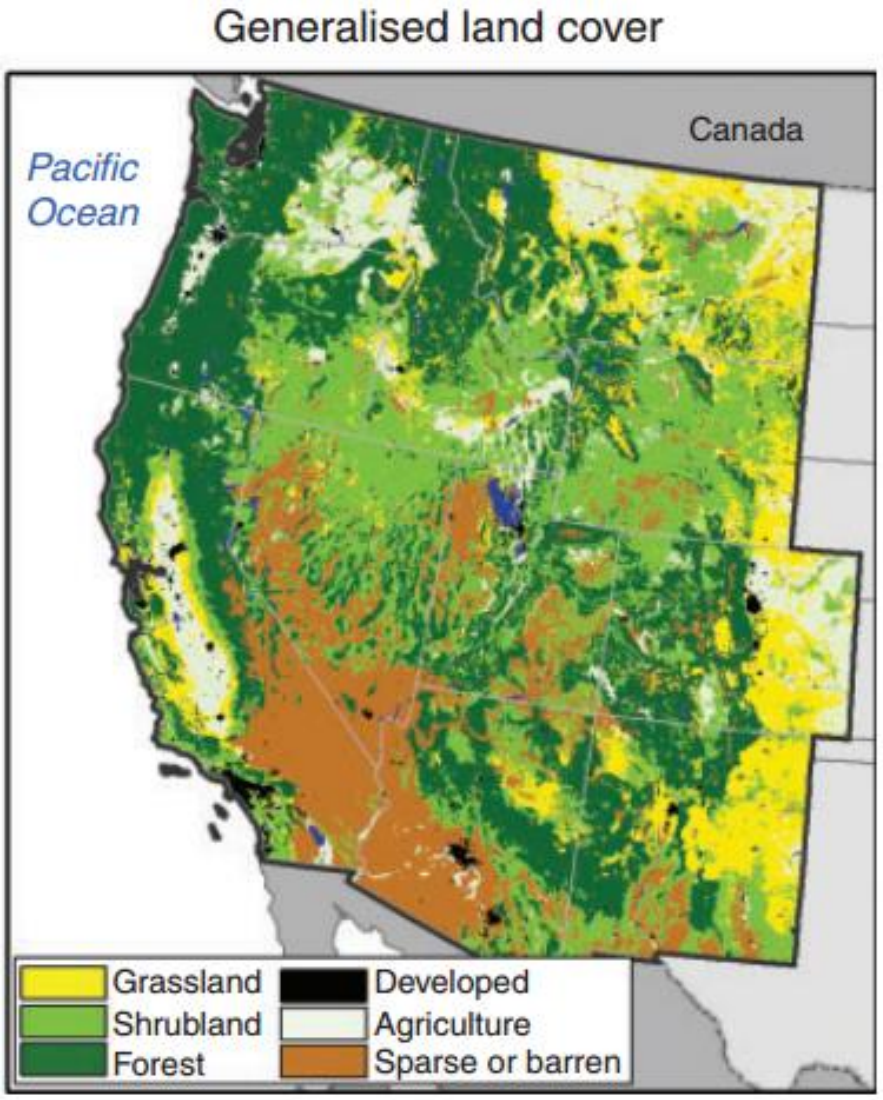
Comparing climate- and fuel-limited ecosystems

Climate Limited	Fuel Limited
*Mesic environments	*Xeric environments

Western U.S.

**** How are large fires spatially distributed across the western U.S.?***

**** Is there evidence for the intermediate resource hypothesis?***

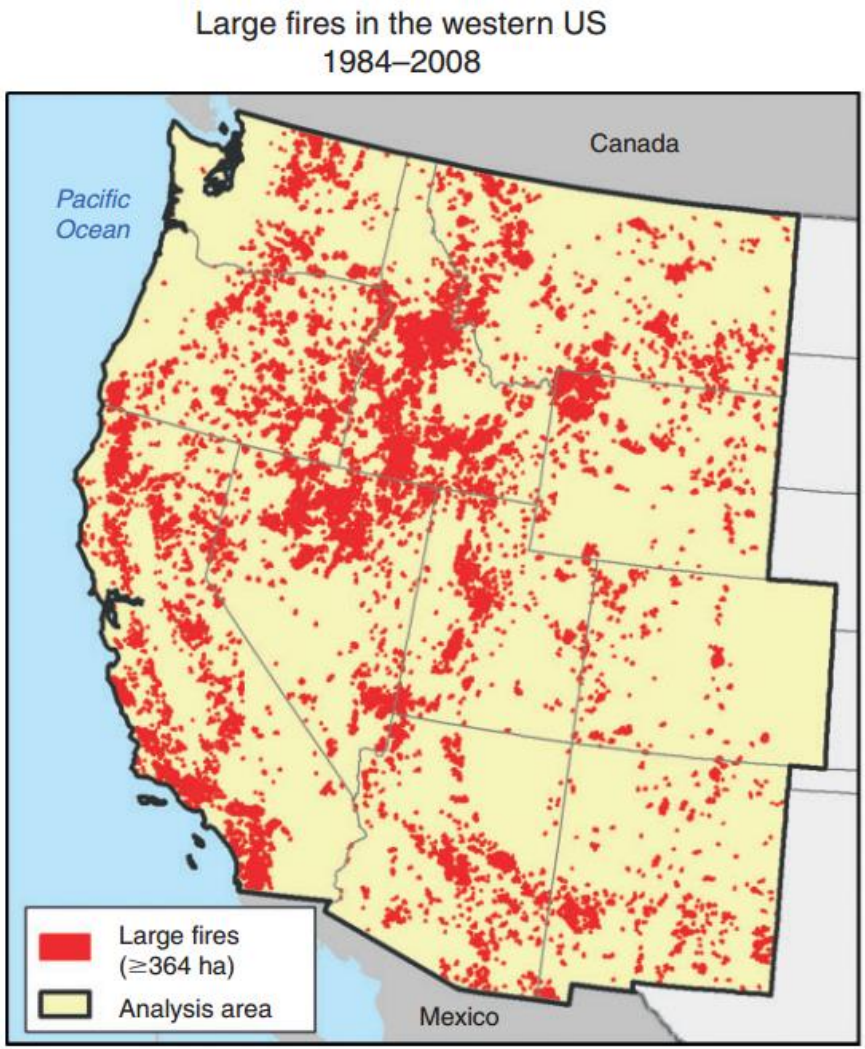


Parisien *et al.* 2012 *IJWF*

Western U.S.

**** How are large fires spatially distributed across the western U.S.?***

**** Is there evidence for the intermediate resource hypothesis?***

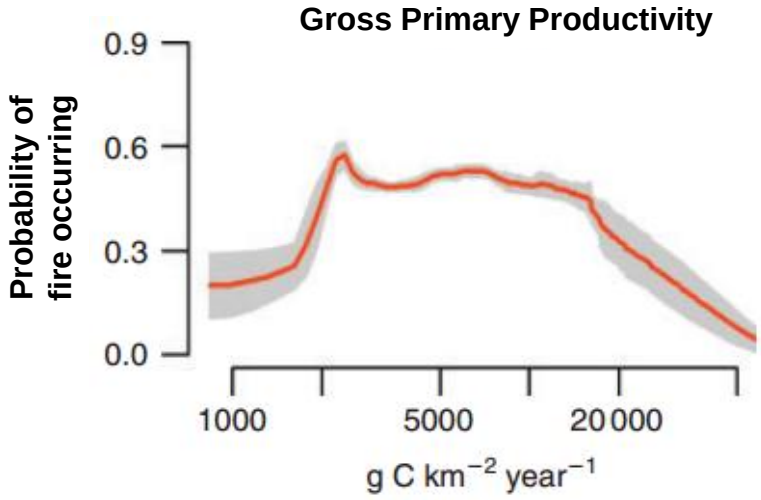


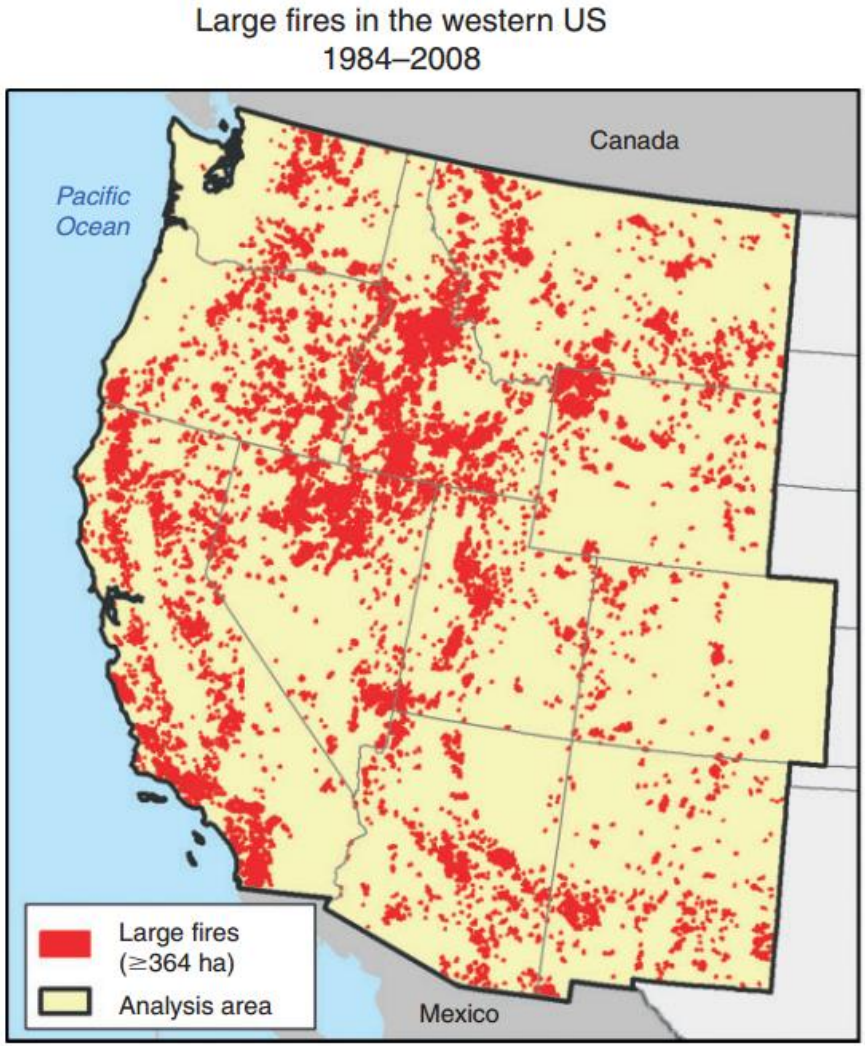
Parisien *et al.* 2012 *IJWF*

Western U.S.

**** How are large fires spatially distributed across the western U.S.?***

**** Is there evidence for the intermediate resource hypothesis?***

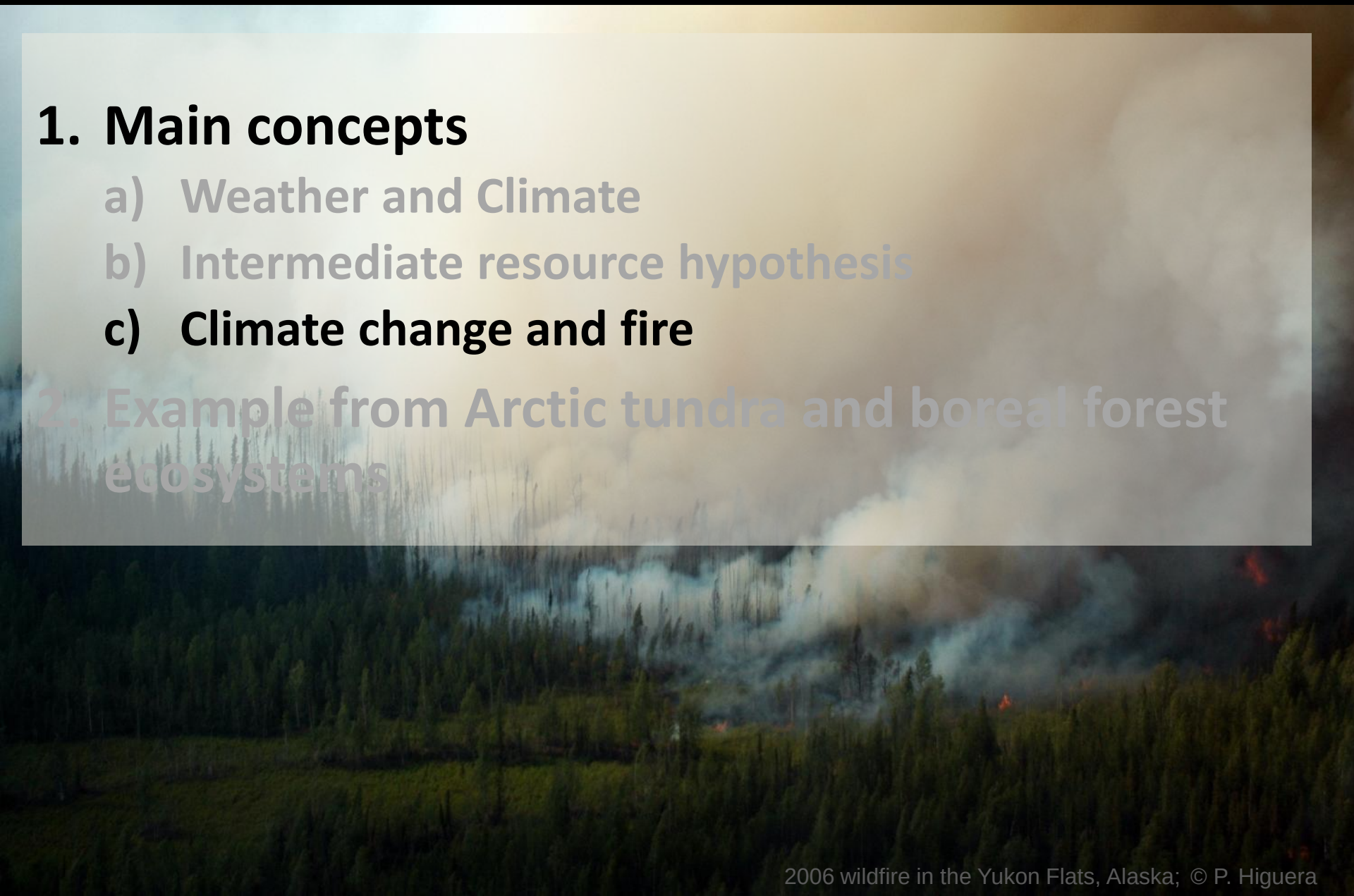




Parisien *et al.* 2012 *IJWF*

Outline

1. **Main concepts**
   a) Weather and Climate
   b) Intermediate resource hypothesis
   c) **Climate change and fire**
2. Example from Arctic tundra and boreal forest ecosystems



2006 wildfire in the Yukon Flats, Alaska; © P. Higuera

Motivation

**** Why study fire-climate relationships? Why are they important to understand?***

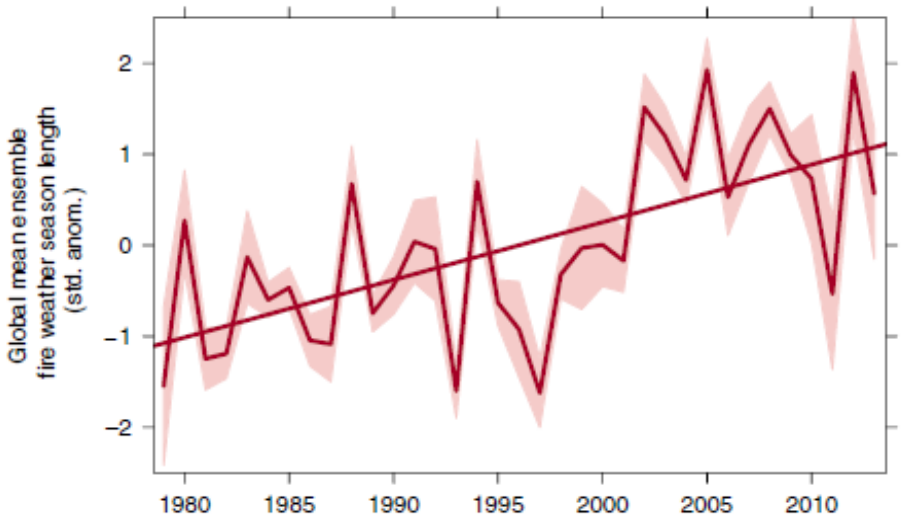
**** To understand how fire activity may respond to ongoing and future climate change.***

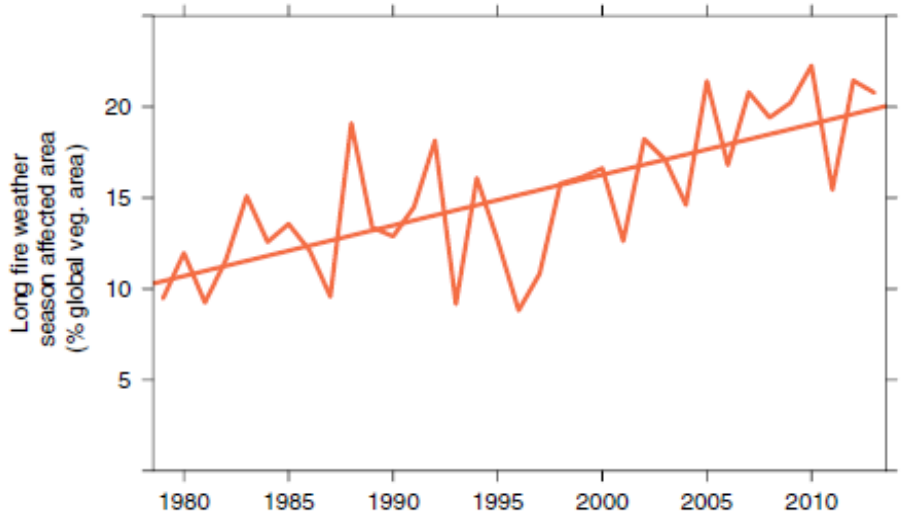
Recent changes in climate

**** Recent global changes in fire season length***

**** Fire season length has been increasing***

**** On average, more regions are experiencing longer fire seasons than 30 years ago***





Jolly *et al.* 2015 *Nat Clim Change*

Ex. Responses to climate change in western U.S.

* ***Increase in fire frequency starting ~1985***
  - ***Across elevations***

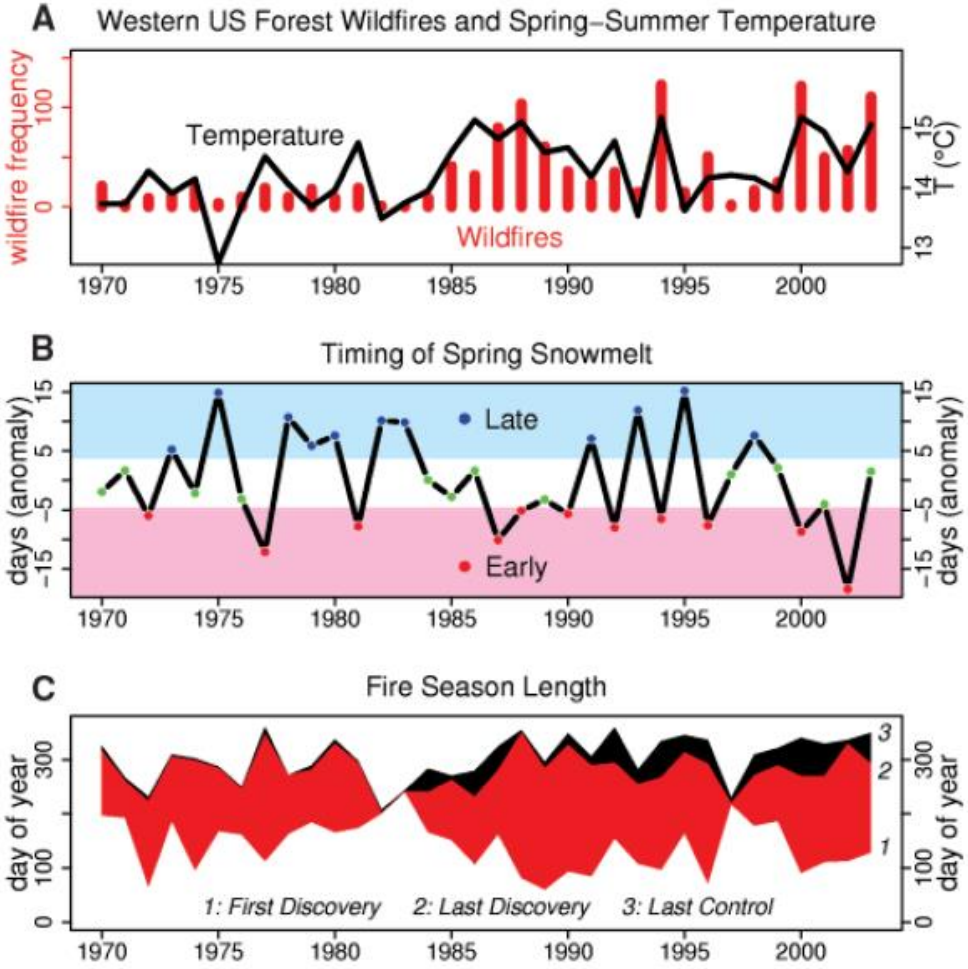
* ***Why?***

* ***Direct link to climate change:***

Warmer spring, summer temps & drier winters

→ ***Earlier snow melt***

→ ***Longer fire seasons & drier fuels***



Westerling *et al.* 2006 *Science*

Fire-climate relationships: main concepts

❖ Intermediate resource hypothesis

- Fuel-limited: meteorological/ambient conditions conducive for burning; low fuel availability
- Climate-limited: meteorological/ambient conditions too wet for burning ; high fuel availability

❖ Climate change

- Fire seasons are becoming longer and affecting more area
- Climate change has direct effect on fire frequency and size
- Ex. (Westerling *et al.*):

Warmer/drier Climate → Earlier snow melt → Longer fire seasons & drier fuels

Outline

1. Main concepts
   a) Weather and Climate
   b) Intermediate resource hypothesis
   c) Climate change and fire
2. **Example from Arctic tundra and boreal forest ecosystems**

2006 wildfire in the Yukon Flats, Alaska; © P. Higuera

Example from Arctic and boreal ecosystems

Ecography 39: 001–012, 2016
doi: 10.1111/ecog.02205

Subject Editor: Jessica Blois. Editor-in-Chief: Miguel Araújo. Accepted 30 March 2016

Climatic thresholds shape northern high-latitude fire regimes and imply vulnerability to future climate change

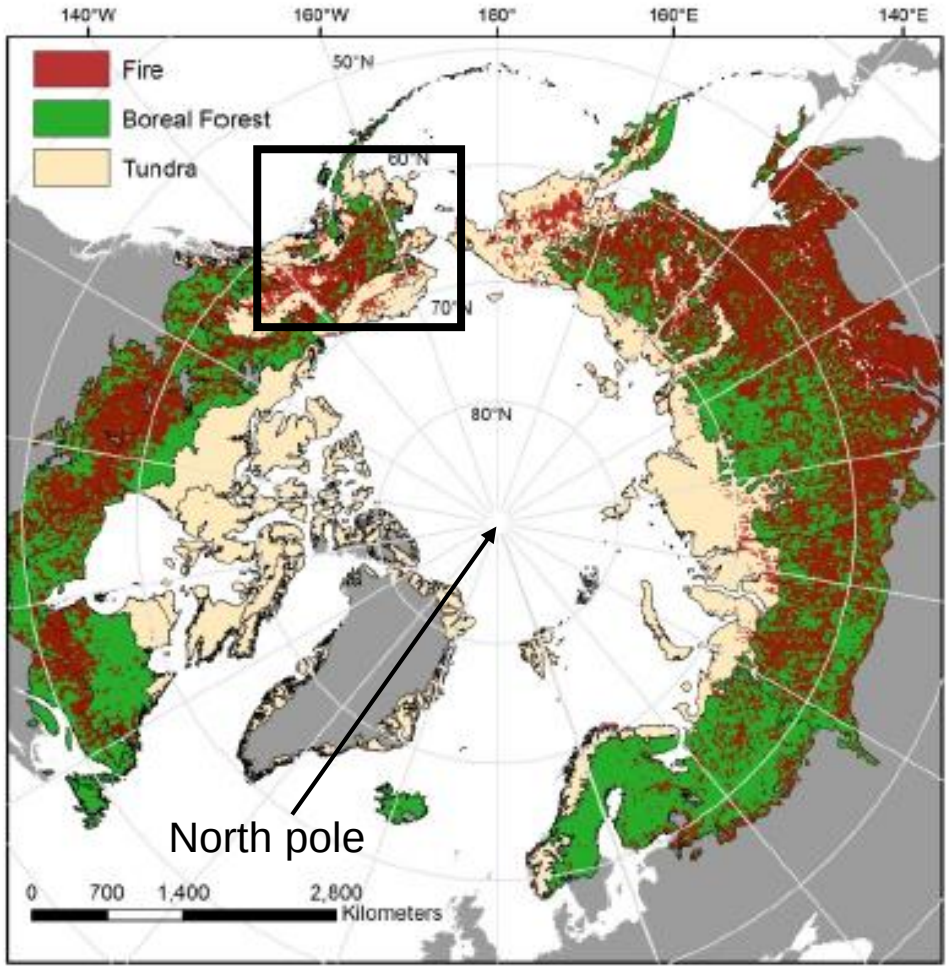
Adam M. Young, Philip E. Higuera, Paul A. Duffy and Feng Sheng Hu

A. M. Young, Dept of Forest, Rangeland, and Fire Sciences, Univ. of Idaho, Moscow, ID, USA. – P. E. Higuera (philip.higuera@umontana.edu), Dept of Ecosystem and Conservation Sciences, Univ. of Montana, Missoula, MT, USA. – P. A. Duffy, Neptune and Company, Lakewood, CO, USA. – F. S. Hu, Dept of Plant Biology, Univ. of Illinois, Urbana, IL, USA, and Dept of Geology, Univ. of Illinois, Urbana, IL, USA.

Where are Arctic tundra and boreal forests?

Distribution of boreal forests and tundra ecosystems

- **Majority of land area above 55° N**
- **Characterized by cool, short summers and long, cold winters**

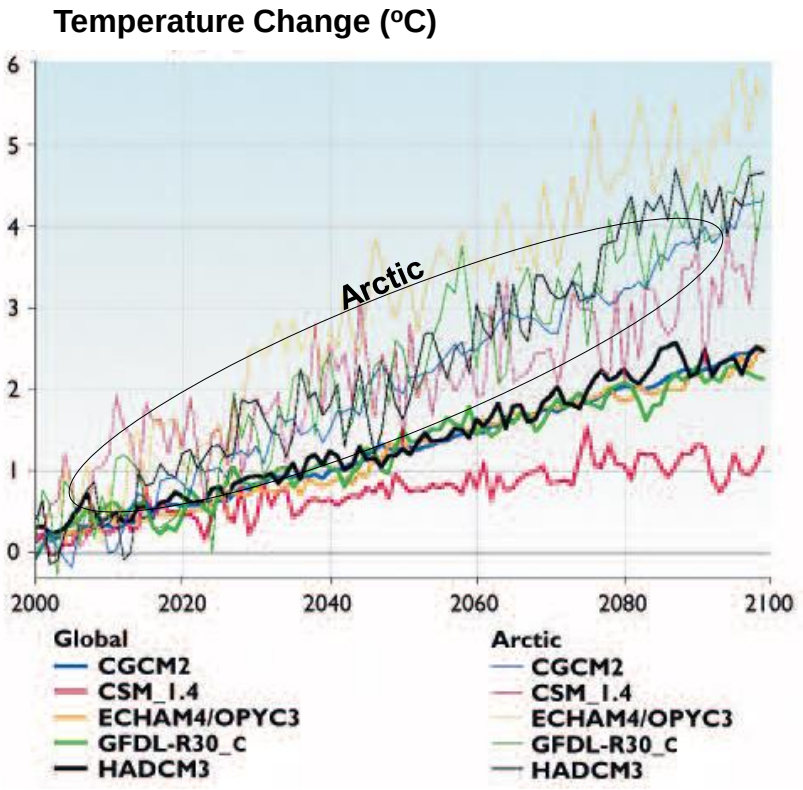


Wildfire and climate change

What will happen in boreal forest and tundra ecosystems under a changing climate?

How might fire regimes shift in response to climate?

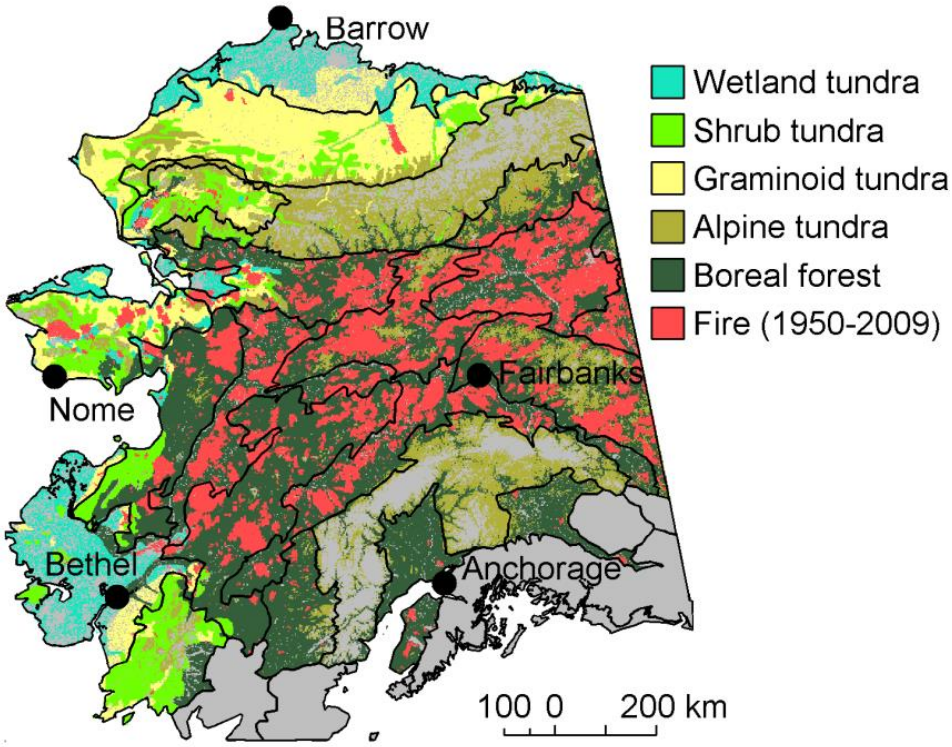
How might these fire-regime shifts occur spatially and temporally?

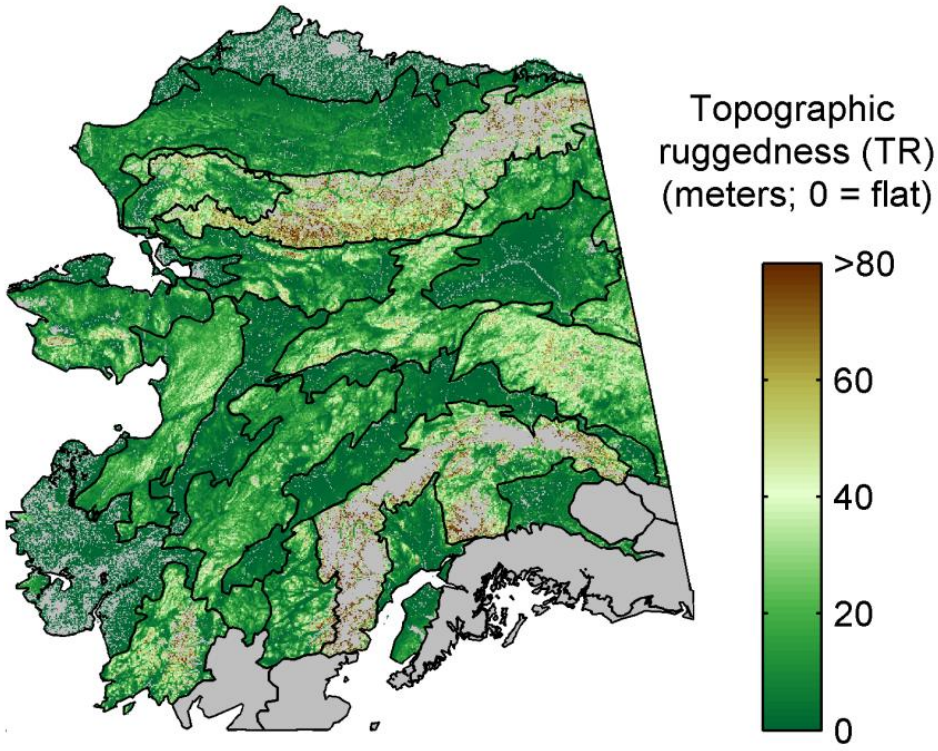


ACIA. 2004

Explaining patterns in fire activity

Q: What controls this spatial pattern?



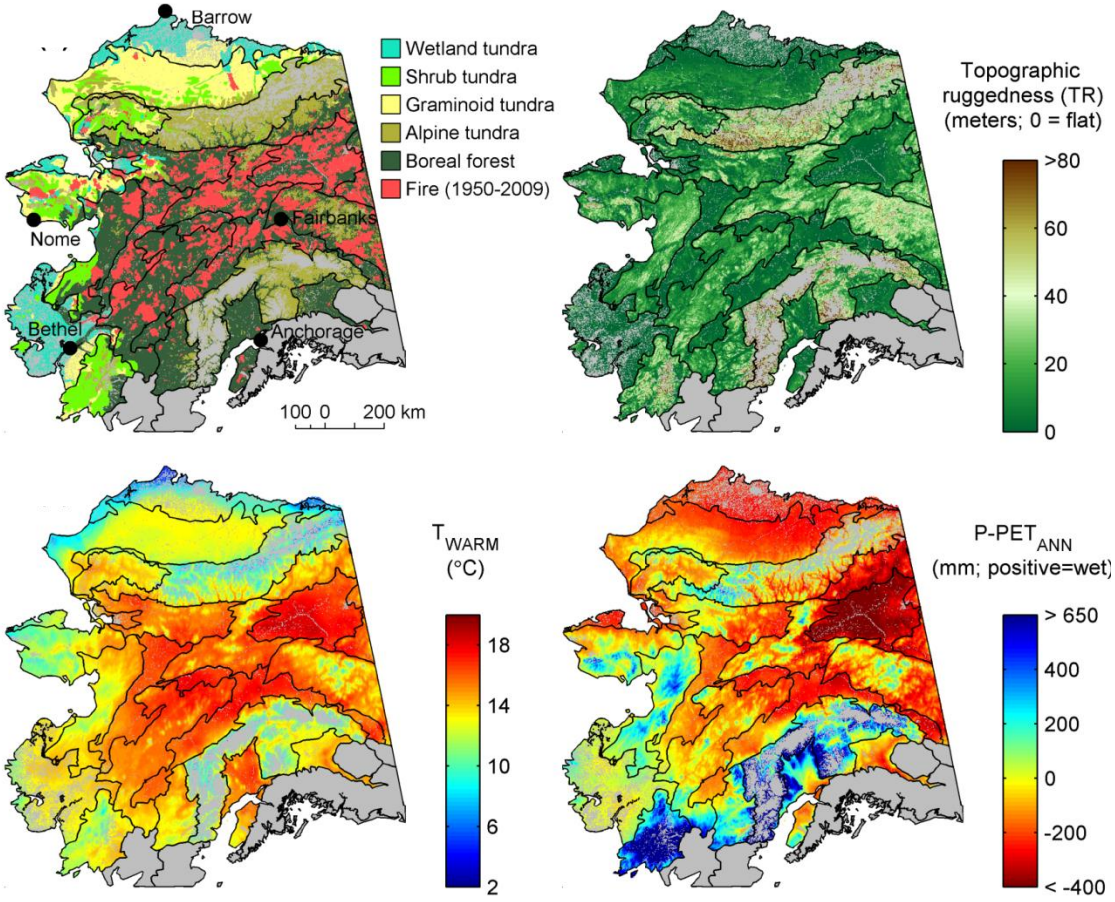


Young *et al. In Press Ecography*

Quantifying fire-regime controls

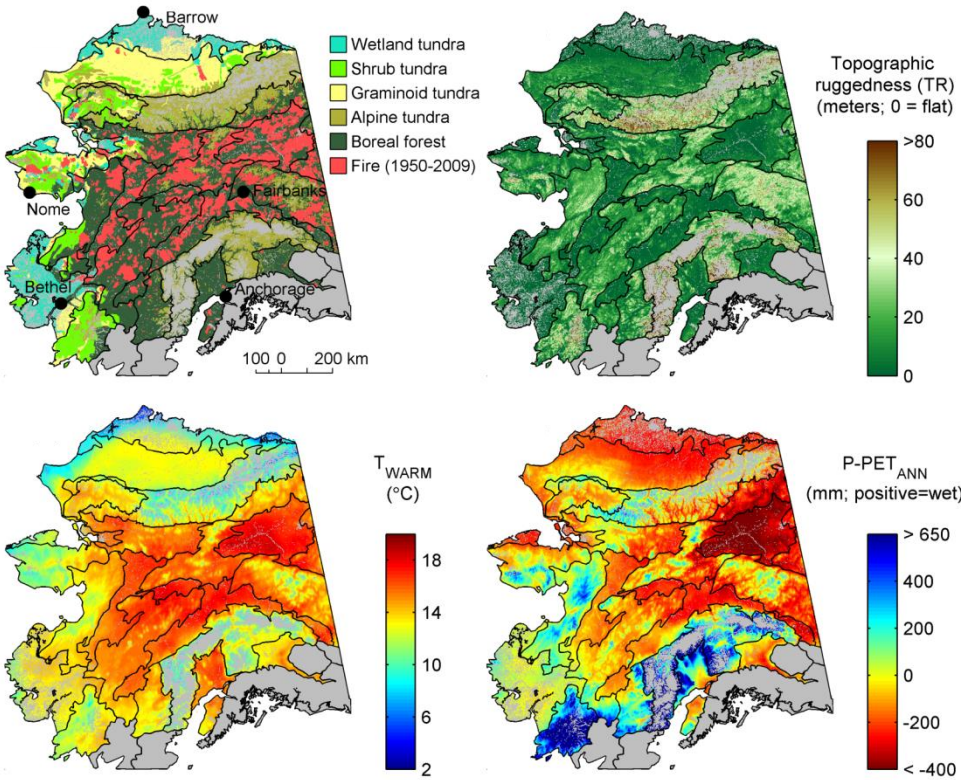
Statistical modeling

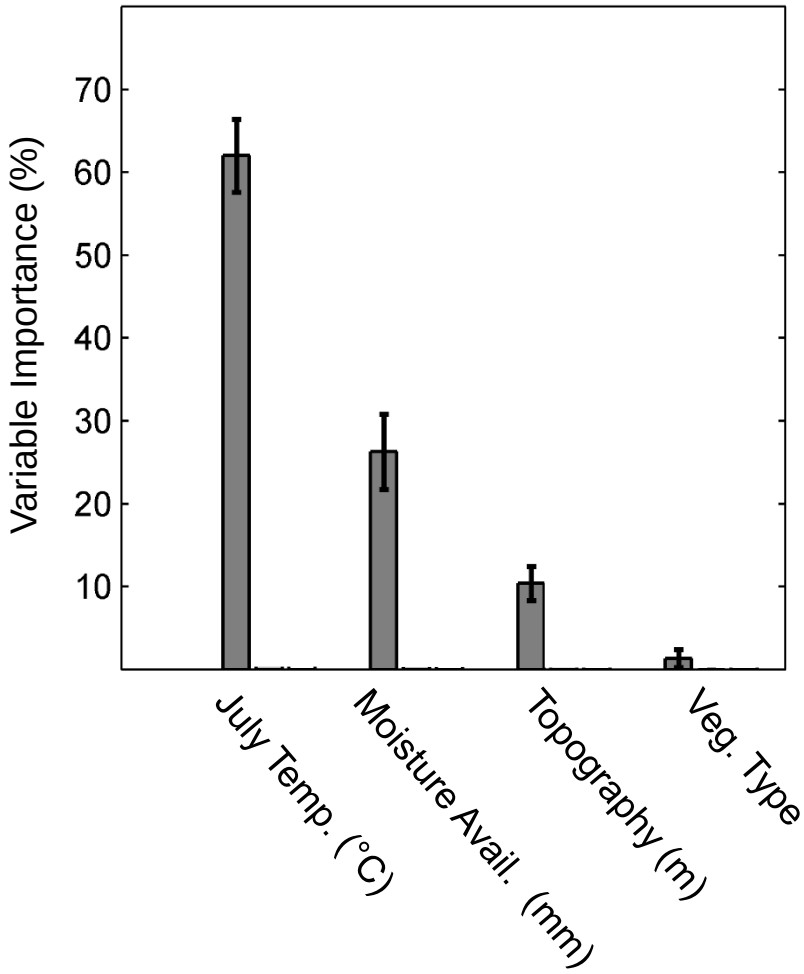
Fire = *f*(climate, veg, topography)



Fire-regime controls

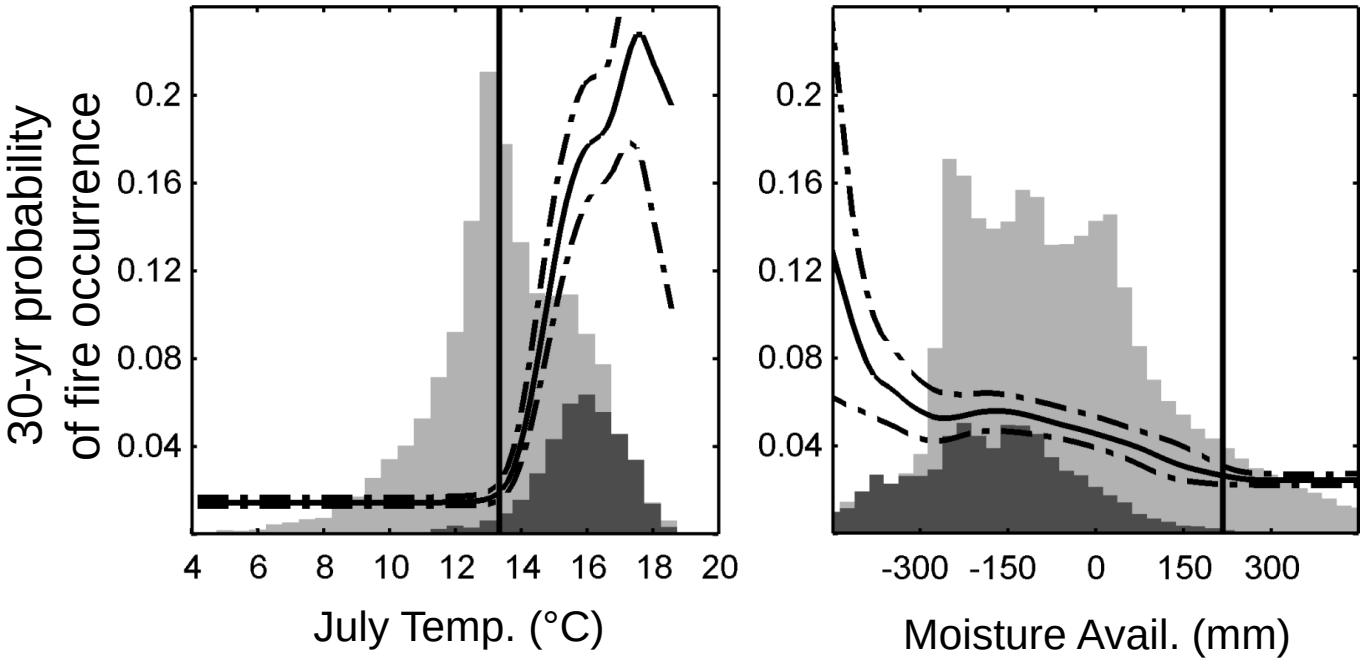
- **Temperature and moisture most important**





Fire-regime controls

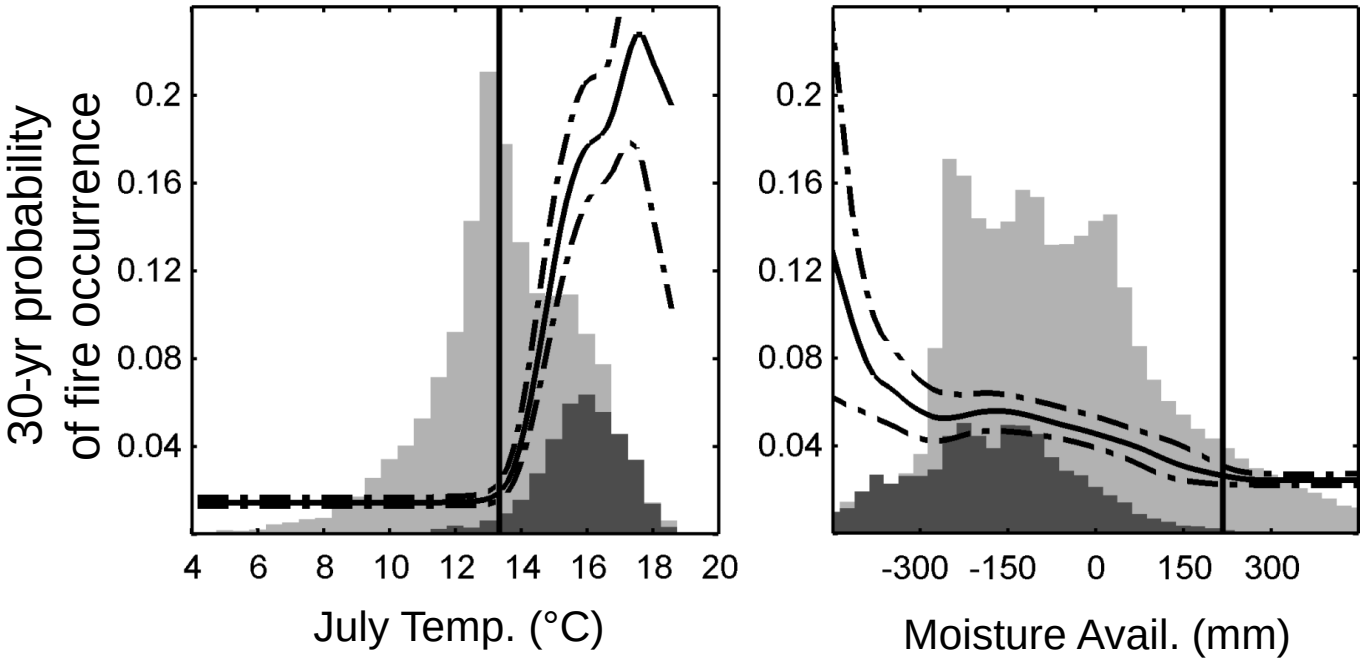
Climatic controls



Young *et al. In Press Ecography*

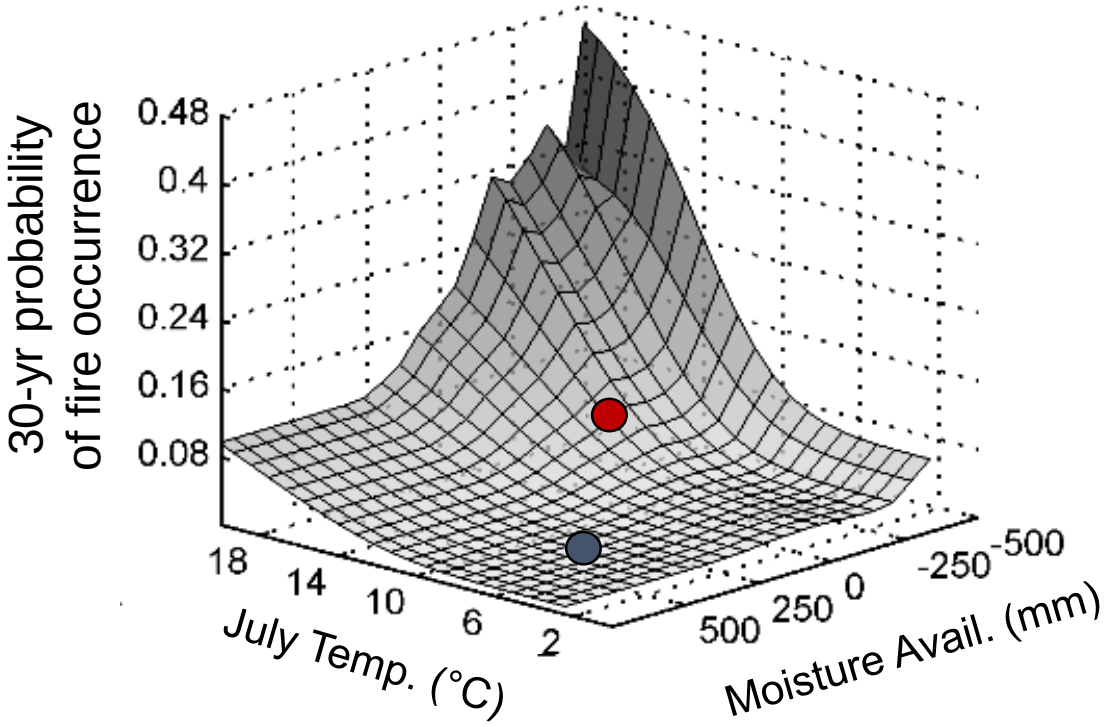
Fire-regime controls

Why do these thresholds matter?



Young *et al. In Press Ecography*

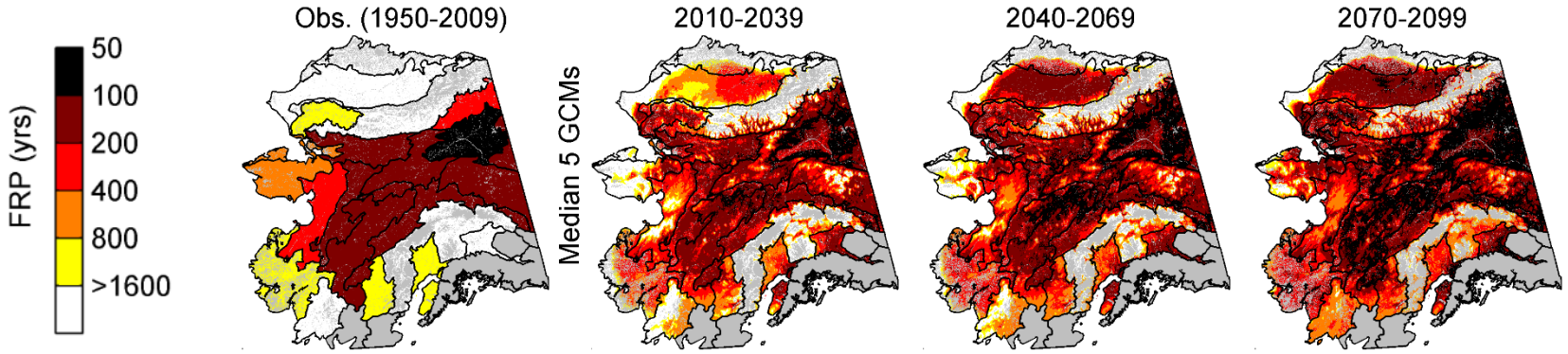
Climatic interactions



***Different levels of vulnerability to climate-induced shifts in fire activity**

Young *et al. In Press Ecogrpahy*

Projecting future fire activity



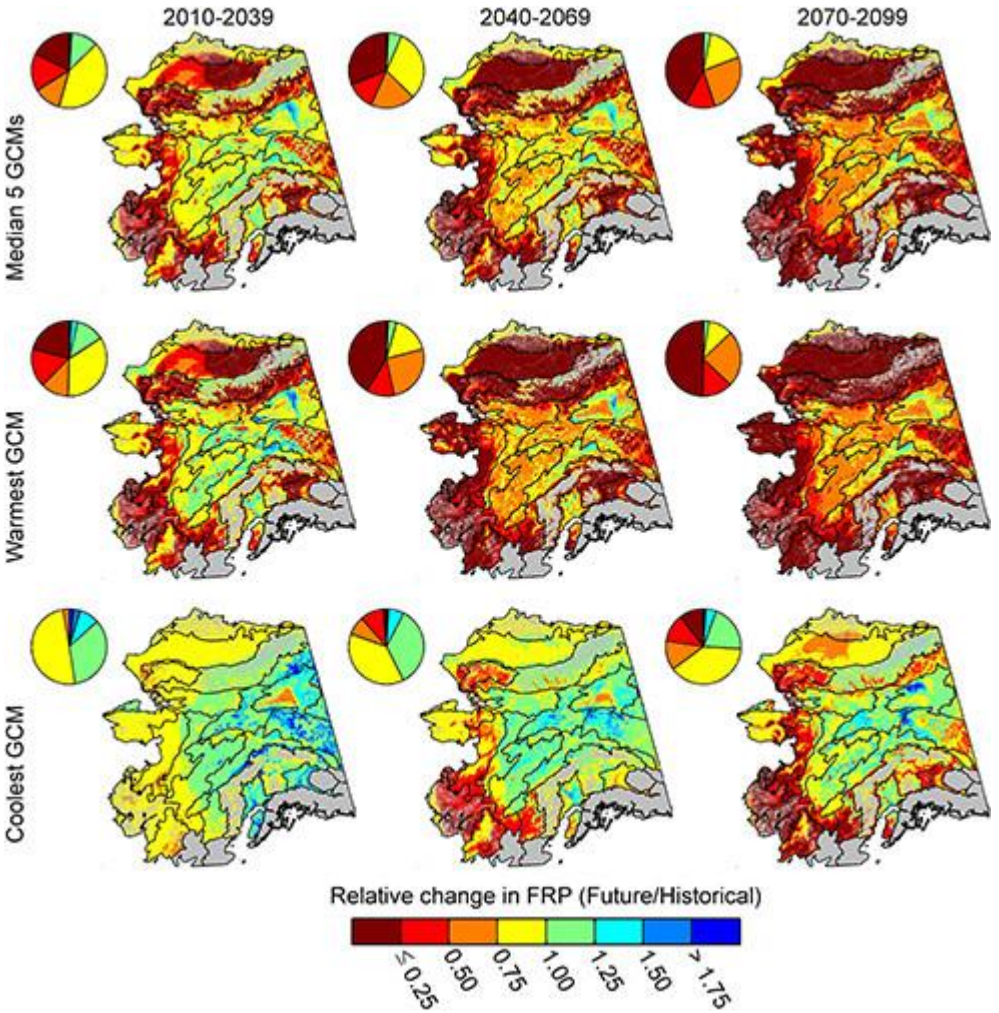
Fire rotation period (FRP) - Length of time it takes burn an area in equal in size to the study area

- **Climate projected to be more conducive to wildfire during 21st-century**
- **Shifts to a more active fire regime**

Projecting future fire activity

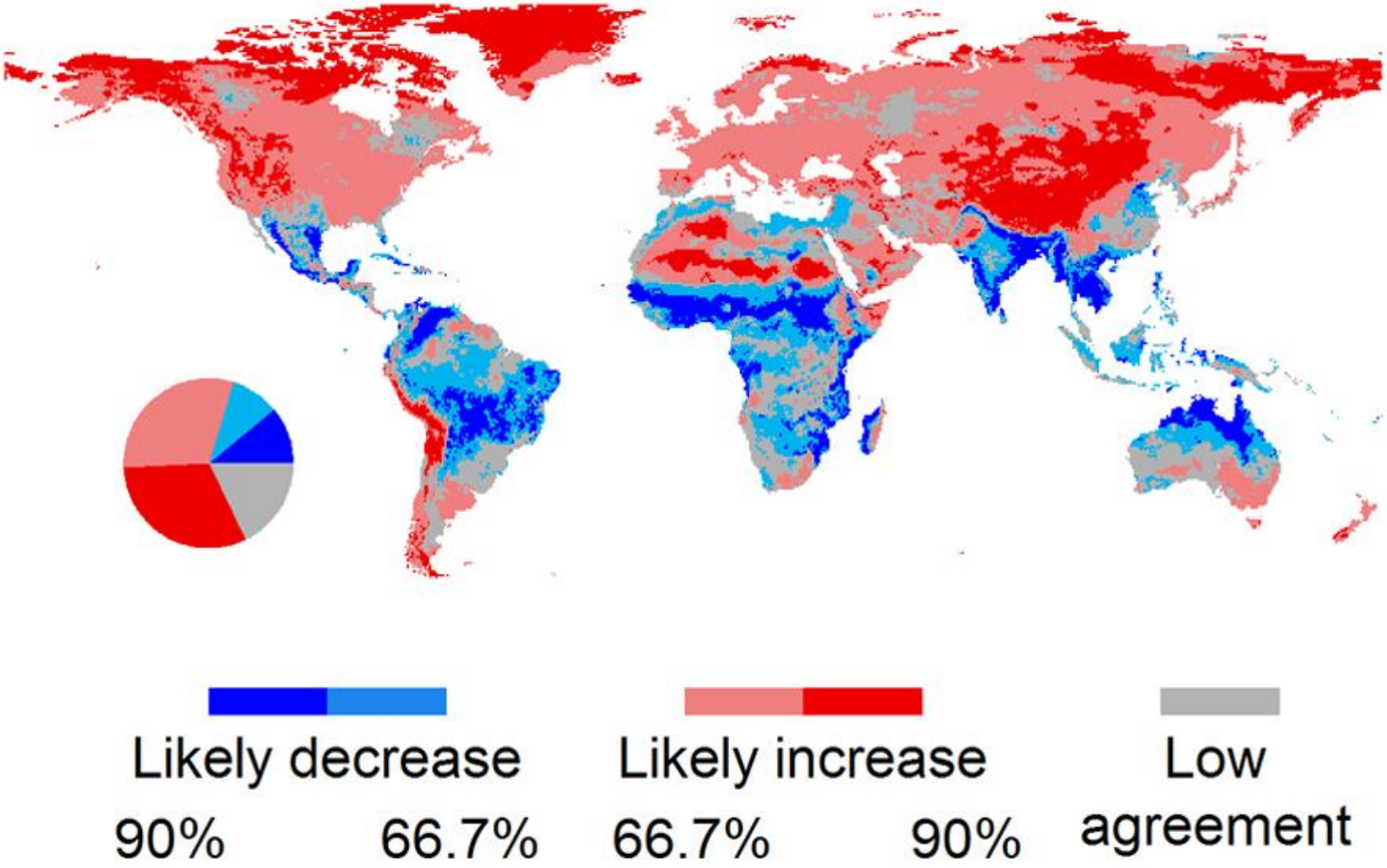
Projected relative changes in fire activity

- **Largest relative changes occurring in forest-tundra regions → near observed climatic thresholds**



Not just Alaska!

Global View: 21st-century projections of fire activity



Moritz *et al.* 2012 *Ecospheres*

Limitations to projecting future fire activity

What is not considered?

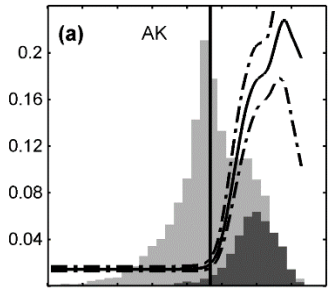
1. ***Changing vegetation***

2. ***Changing ecosystem dynamics***

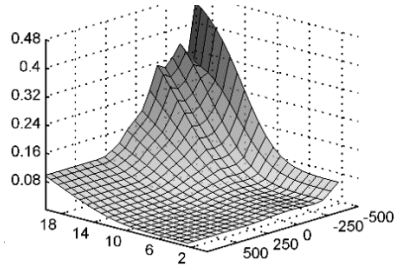
3. ***Changing fire-climate relationships***

Summary – Fire in the Far North

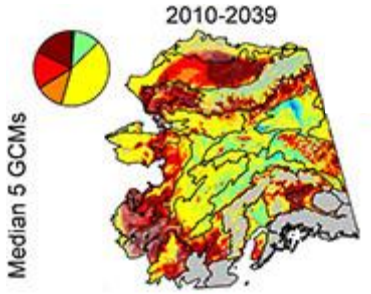
- **Nature of fire-climate relationships is nonlinear → Climatic Thresholds**



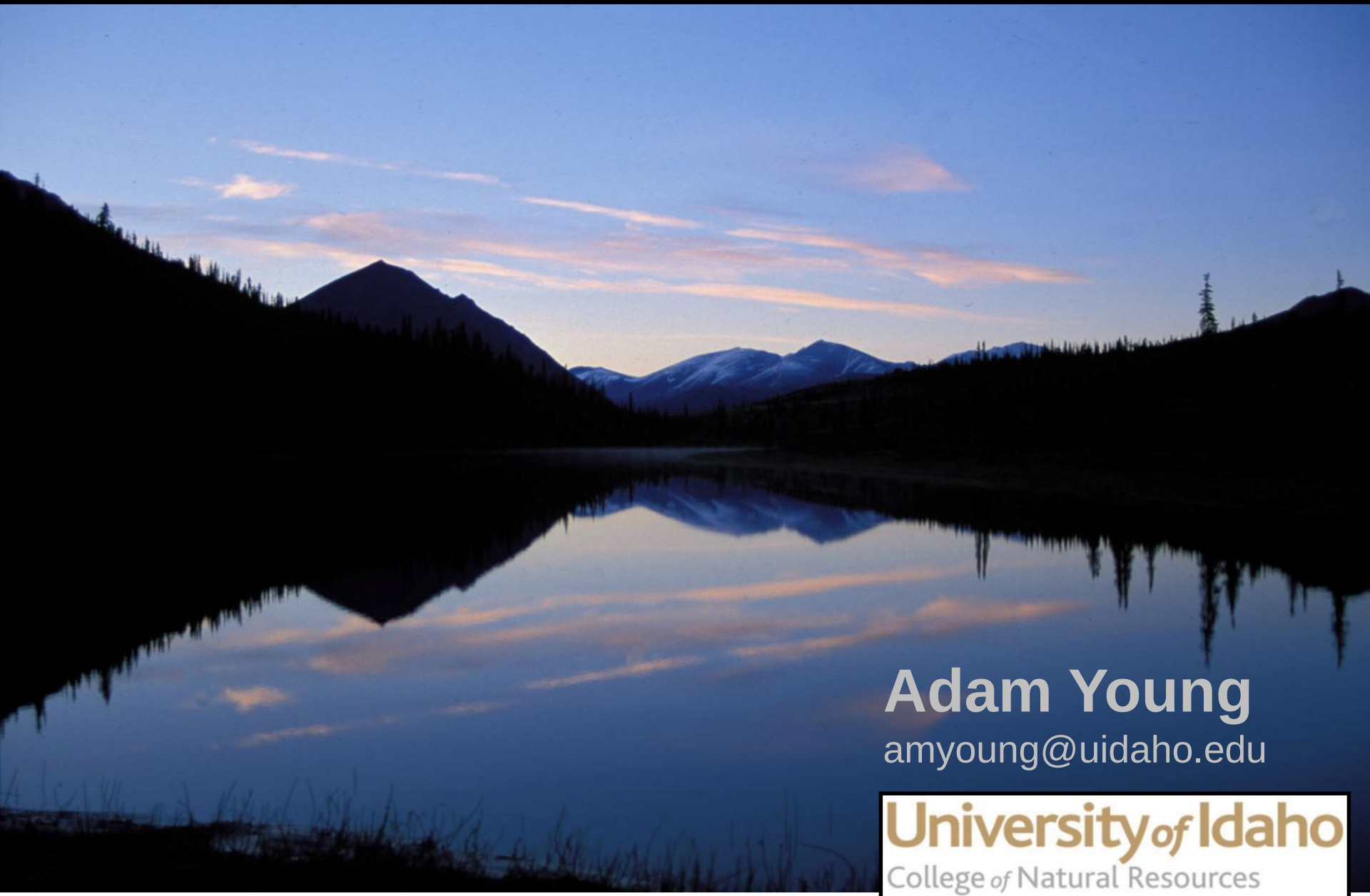
- **Varying levels of sensitivity to climatic thresholds**



- **Fire regimes are more vulnerable to climatic change in some regions**



Questions?



Adam Young
amyoung@uidaho.edu
University of Idaho
College of Natural Resources

Footprint Lake, Brooks Range, 1 am. © P. Higuera